PROFESSOR BACHE'S

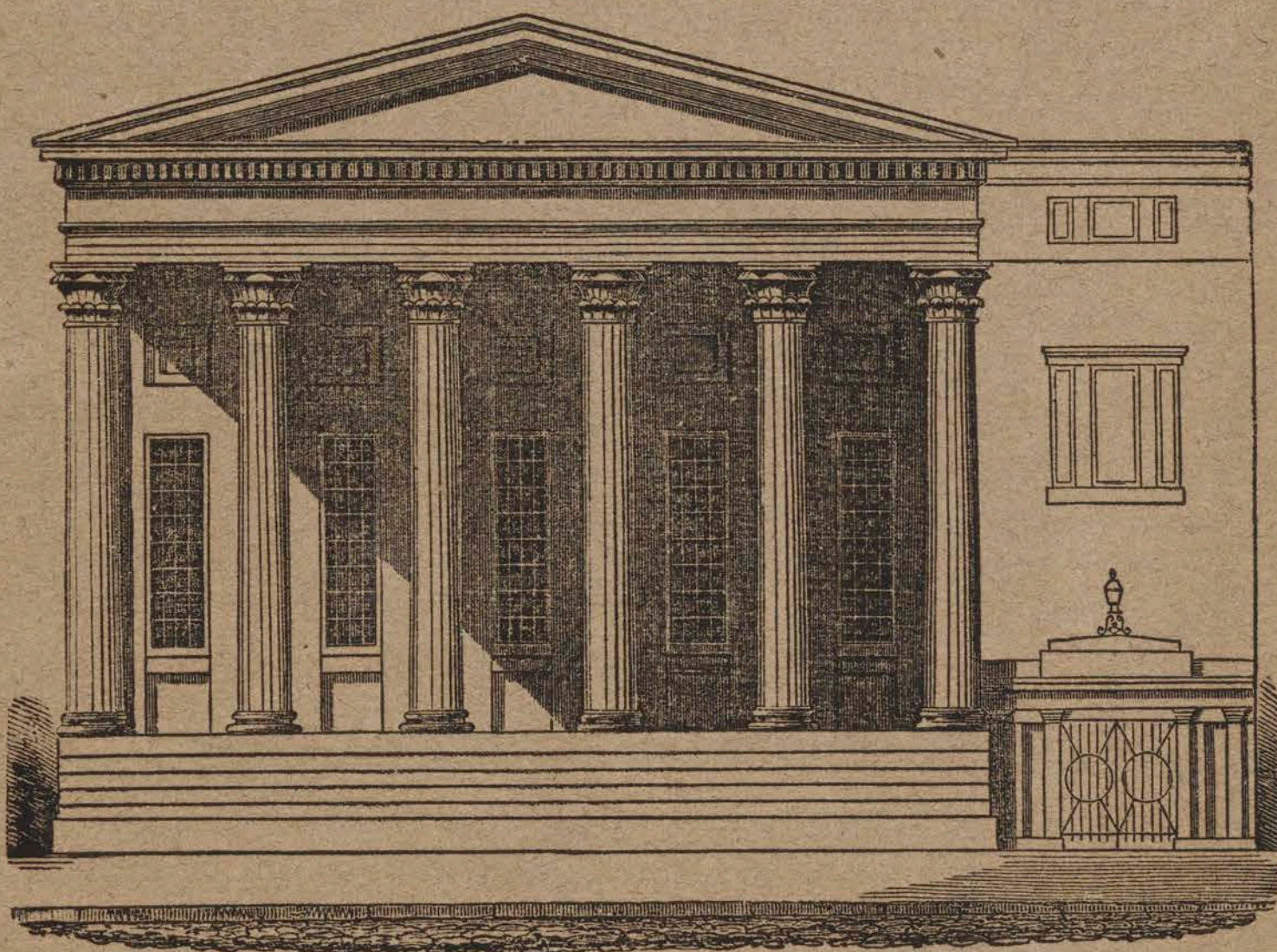## INTRODUCTORY LECTURE

Chemistry

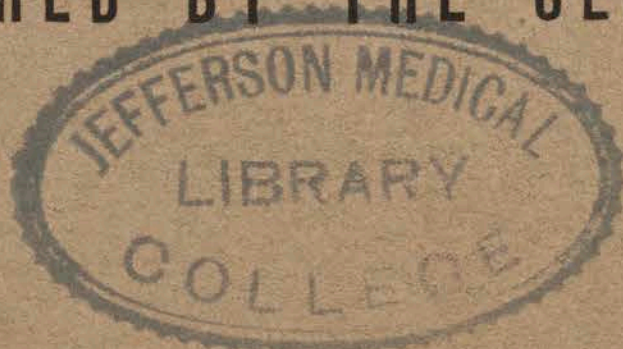DELIVERED IN

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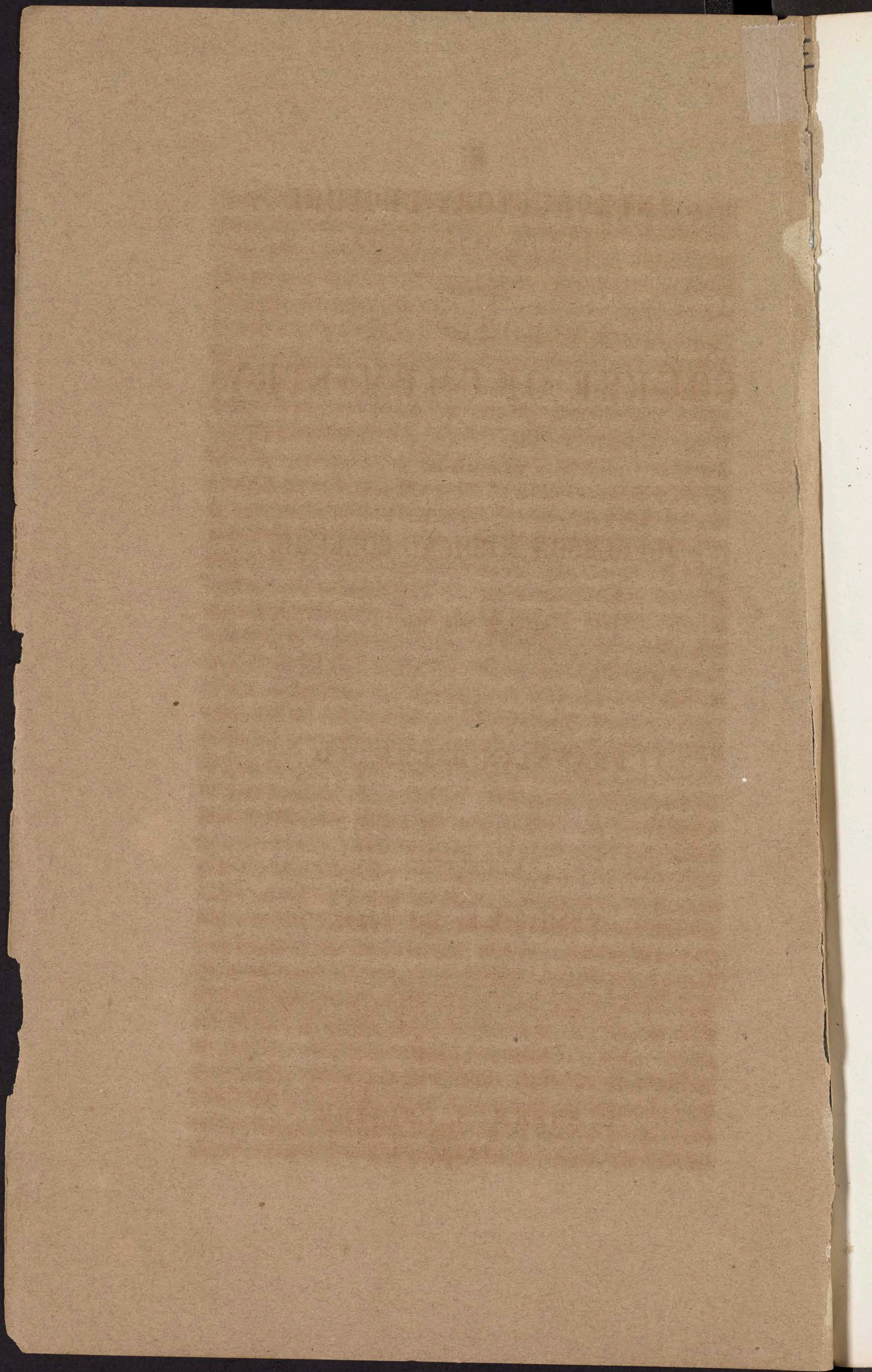
Of Philadelphia,

OCTOBER 16, 1849.

GILBERT & GIHON Sc.

PUBLISHED BY THE CLASS.

INTRODUCTORY LECTURE

TO THE

COURSE OF CHEMISTRY,

DELIVERED IN

JEFFERSON MEDICAL COLLEGE,

OCTOBER 16th, 1849.

BY

FRANKLIN BACHE, M.D.

Published by the Class.

CORRESPONDENCE.

JEFFERSON MEDICAL COLLEGE, October 24th, 1849.

PROFESSOR FRANKLIN BACHE,

Dear Sir,—It is with the greatest pleasure that we, a Committee appointed by the Class, fulfil their instructions in respectfully soliciting for publication, a copy of your Introductory, delivered on the 16th of October.

Yours, very respectfully,

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J. H. FITTS, Ala.	

PHILADELPHIA, October 25th, 1849.

Gentlemen,—I yesterday received your letter, in which you do me the honour to request a copy of my Introductory, delivered on the 16th instant, for publication. It gives me pleasure to comply with your wishes, and, accordingly, I place the manuscript at your disposal.

I am, gentlemen,

Very sincerely, your friend,

FRANKLIN BACHE.

To Messrs. C. DORSEY BAER,
W. S. COCHRAN,
J. G. BROOKS, and others,
Committee of the Class of Jefferson Medical College.

INTRODUCTORY.

THE season has again arrived, gentlemen, when it becomes my grateful duty to open my annual course of chemical lectures in this College. In resuming my labours as a teacher, how delightful is it to find myself surrounded by so large an assemblage of young men, coming from various parts of our extended country, all animated with the desire of perfecting themselves in the knowledge of the medical sciences. Many of you are known to me, as my friends and pupils of former years; but a still larger number are here for the first time, attracted to our city by the ample facilities afforded by it for the pursuit of medical studies.

Under the influence of a wish to vary my introductory addresses, from year to year, with new subjects of chemical interest, it has often occurred to me that a report of the annual progress of chemical science, more especially in its relations to medicine, might prove both interesting and instructive. But there are insuperable obstacles in the way of doing this as it ought to be done. Even if I felt myself competent to undertake a task of such difficulty, and had access to the necessary books and periodicals, still the time allotted to an introductory lecture would allow of my presenting but a meagre sketch, necessarily too imperfect to answer any useful purpose. Under the circumstances in which I am placed, I shall merely give you a general idea of the several subjects embraced by my course, presenting them in the order in which they are taken up for discussion; together with incidental notices of such new facts and observations, as may be calculated to arrest your attention, and, at the same time, to impress you with a proper sense

of the importance of chemical science as a branch of medical study.

Material substances are conveniently divided into those which have no appreciable weight, and those which are ponderable. The imponderables embrace light, heat, electricity, and magnetism. These subtile forms of matter are of great interest, and evidently play an important part in the economy of nature. The influence of *light* on organized beings, and the intimate relation of *heat* to vitality, are apparent to the most superficial observer. How striking is the effect of heat on vegetables. In winter, their vitality is suspended; in spring, they are called into renewed life by the genial warmth of the sun! Although we are not certainly acquainted with the nature of the principle which traverses the nerves, and forms the medium of communication between the brain and the various parts of the system, yet we cannot fail to be struck with the strong analogy between its effect, and that of a current of *electricity*, passed through a nerve and muscle. Indeed, Matteucci, of Pisa, by means of his muscular piles, has demonstrated the existence of muscular electrical currents, and states his belief that the property of muscles, immediately connected with these currents, is identical with Haller's irritability, at present usually termed contractility. The subject of *magnetism* likewise deserves to be studied by medical men; on account as well of its intimate connexion with electricity, as of its growing importance as a therapeutic agent.

Before taking up the individual ponderable bodies, I shall treat of the general subjects of attraction, the laws of combination and the atomic theory, chemical symbols, nomenclature, the pressure of the atmosphere, and specific gravity. The laws of combination lead directly to the establishment of invariable ratios, denoting the relative weights in which the different elements combine. These invariable ratios are expressed by numbers called equivalents, which are attached to the several elements, and denote the relative weights in which they unite in their

primary combinations. As the equivalents denote relative and not absolute weights, different series of numbers may be selected to express the admitted relation; and each series is necessarily equally correct. Accordingly, the element that shall have its equivalent assumed, and the number that shall be assigned to it as the basis for calculating the equivalents of the remaining elements, are determined on grounds of convenience. Now, chemists are not agreed on this point, and two sets of numbers are in use. On the continent of Europe, 100 is assumed for oxygen, as the starting point of the equivalents; in England and this country, 8 is generally adopted for the same element, founded on the assumption of unity for hydrogen.

It has long been a matter of controversy among chemists, whether a number, forming a common divisor of all the equivalents without a remainder, can be found; that is, whether a number can be discovered that will be contained in each equivalent an exact number of times. If such a number can be found, it obviously follows, that all the equivalents may be expressed by whole numbers; and it would be a gratuitous departure from simplicity to denote them by decimals. Let us examine this question with reference to the equivalent numbers of several important elements, as determined by chemists of admitted accuracy, adopting unity for hydrogen. Thus, Berzelius gives the equivalent of carbon at 6·13, of nitrogen at 14·19, and of sulphur at 16·08, the latter number being a corrected one, given by this chemist not long before his death. Erdmann and Marchand make the number for carbon exactly 6, and that for sulphur, exactly 16. Dumas and Stass also make the equivalent of carbon 6; while Liebig and Redtenbacher make it 6·07, and Baron von Wrede 6·01. Marchand determines the equivalent of nitrogen, after very elaborate experiments, to be 14·02; while L. Svänberg makes it 13·95. Now, if we adopt the equivalents of these three elements, as determined by Erdmann and Marchand, and employ unity as the divisor, we find that it divides them exactly in the cases of carbon and sulphur, and very nearly so in the case of nitrogen; and it

deserves to be remarked, that the recent corrections of Berzelius's numbers by other experimenters, are made in those which deviate considerably from being exact multiples of the assumed divisor; while those equivalents of the Swedish chemist, which approach very nearly to exact multiples, are scarcely modified by recent determinations. These results seem to establish the existence of a law, that all the equivalents contain the same number exactly, without a remainder; and it further appears, that the number thus contained may be assumed to be equal to the equivalent of hydrogen, which is the largest number that can be assumed; since the contained number cannot possibly exceed any one of the equivalents, which are the numbers in which it is to be contained. The law is certainly supported by the equivalents of the several elements which have the smallest combining weights; and these are the equivalents to which the assumed divisor, the equivalent of hydrogen, bears the greatest ratio, and in regard to which, if the law were not well founded, any considerable deviation from the whole number equivalent would be most fatal to it. Nevertheless, it must be admitted, that the equivalent of chlorine, which is by no means a large number, compared with that of hydrogen, does not conform to the law.

The doctrine of volumes, in connexion with the specific gravity numbers, often enables us to deduce the equivalent of an element. The equivalent volumes of the gases are well determined, and universally admitted to form very simple multiples and submultiples of each other. Biot and Arago were the first to calculate on data of this kind, the equivalent of carbon; and the determination of the same equivalent by Baron von Wrede, already cited, was deduced in a similar manner. Thus, as oxygen does not change its volume when it becomes carbonic acid, it is obvious that the weights of equal bulks of oxygen and carbonic acid, that is their specific gravities, must represent their equivalents. Again, the difference between the specific gravity of carbonic acid and of oxygen must represent the weight of the carbon, combined with a weight of oxygen, represented

by its specific gravity; in other words, the equivalent of
carbon. Proceeding in a similar manner, the equivalent of
chlorine may be calculated. Thus, if we grant that hydro-
gen and chlorine unite in equal volumes, it follows that the
specific gravity of these gases gives the ratio of their equiva-
lents. Accordingly, the equivalents of hydrogen and chlo-
rine, adopting Berzelius's numbers for their specific gravity,
will be as the numbers ·0688 to 2·47; that is, as unity to
35·9; and, if the specific gravity of chlorine were 2·4768,
instead of 2·47, the ratio would be exactly as 1 to 36.

Within a few years, Berzelius has announced a curious
and important view, that certain simple bodies are capable
of existing in several states, and, in some instances, of
carrying their peculiar conditions into their combinations.
This general fact he expresses by the term *allotropism*.
Thus, he recognises three states in which the carbonaceous
element may exist; namely, those of charcoal, plumbago,
and diamond. He also conceives that sulphur and phospho-
rus are presented in three allotropic states, while silicon,
chromium, and titanium exist in two. The last three
elements, severally, form two isomeric oxides, which may
be plausibly viewed as derived from the distinct allotropic
states of the elements themselves; and Berzelius conjectures
that tin, antimony, columbium, and tellurium have two
undiscovered allotropic states, corresponding to the isomeric
oxides of each.

As illustrating the subject of allotropism, it may be well,
in this place, to mention ozone. This name was given by
Schoenbein, in 1841, to the material cause of the odour,
perceived upon making strong electrical discharges, being
derived from the Greek word ὄζω, I have a smell. The
same odour is communicated to water by the decomposing
influence of a galvanic battery. This fact induced Schoen-
bein at first to conjecture that water contained a small
quantity of a compound, previously unknown, of hydrogen
with ozone, which latter he supposed to be a new electro-
negative element. When water is subjected to a galvanic
current, this new compound was assumed by him to be

decomposed, with the effect of liberating the ozone, which, in a free state, was alleged to have the peculiar odour observed. Subsequently, Schoenbein succeeded in producing ozone by purely chemical means. This he effected by enclosing pieces of phosphorus in large glass globes, containing moist air, and exposing the whole to a temperature between 54 and 57 degrees. Marignac, having examined the subject, concluded, from his experiments, that the so-called ozone is a peculiar allotropic state of oxygen; and this view, to a certain extent, has been confirmed by De la Rive, who succeeded in producing the ozone of Schoenbein, by subjecting perfectly dry oxygen, slowly passed through a narrow tube, to successive electric sparks. Notwithstanding the coincident results of Marignac and De la Rive, Schoenbein is unwilling to adopt their conclusions. On the contrary, he now expresses his belief that ozone is a compound of water and oxygen, analogous to the deutoxide of hydrogen, or oxidized water. Commenting upon these different views, Berzelius sagaciously suggested, that the compound, now assumed to be ozone by Schoenbein, may, in fact, be an isomeric form of oxidized water, deriving its peculiarities from its containing oxygen in that allotropic state, which, according to Marignac and De la Rive, constitutes true ozone. Thus it appears, so far as researches have been made, that ozone is neither a new element, as at first conjectured by Schoenbein, nor yet a compound previously unknown, but merely a peculiar allotropic modification of the well-known element oxygen.

The subject of chemical nomenclature is one that deserves the particular attention of the student. The names employed by the chemist are not an assemblage of arbitrary terms, but form a systematic terminology, which aids essentially in the comprehension of chemical classification. Certain terminal syllables, or letters, are given to the names of particular classes of substances; as the termination in *um* to denote the metals, and in *a* to designate the mineral and organic alkalies, and the earths. To express compounds, especially salts, the name is generally so constructed as to

indicate the constituents. It is to be regretted, however, that several departures from strict propriety of nomenclature have been tolerated by usage, which are cause of embarrassment to the beginner in chemistry. When I commenced my chemical studies, in 1810, and for many years afterwards, the state of the base, at the maximum of oxidation in a salt, was denoted by the prefix *oxy*. Thus, the salts formed by sulphuric and nitric acid, with the maximum-oxide of iron, were called, severally, oxysulphate and oxy-nitrate of iron. Here the prefix, *oxy*, is intended to indicate the grade of oxidation of the iron; and, if used at all, should have been placed immediately before the word it qualified, so as to make the names read thus:—sulphate and nitrate of oxyiron. Afterwards, the expressions, persulphate of iron and pernitrate of iron, were frequently substituted; the prefix, *per*, taking the place of the prefix, *oxy*, as given in the other examples. In designating the salt of an oxide, derived from a metal forming but one salifiable oxide, the name of the oxide is not usually appended to the name indicating the acid, but the name of the metal of the oxide is added. Thus, the compound of nitric acid with oxide of silver, is generally called nitrate of silver, instead of being designated by the full name, nitrate of oxide of silver. The more concise name will be intelligible to the advanced student; for he will fully understand that, in the salt mentioned, the silver exists in the oxidized state; but the beginner will be embarrassed by it; more especially when he finds that the word "silver" is used in two senses, sometimes to mean metallic silver, at other times oxide of silver; as in the expressions, "sulphuret of silver," and "nitrate of silver."

This mode of nomenclature, of omitting to indicate the state of oxidation of the metal in the base of a salt, becomes perfectly vague, when applied to cases where metals form several salifiable oxides. Thus, the expression, sulphate of iron, is not merely elliptical, but unprecise; for there is nothing in the name to indicate whether the sulphate of the protoxide, or the sulphate of the sesquioxide, is meant.

In the case of salifiable oxides, which have a single name to express them, as, for example, potassa, which, in one word, denotes the protoxide of potassium, the nomenclature of the salts formed is perfectly precise. Thus, the name nitrate of potassa expresses exactly the idea intended to be conveyed, that of a compound of nitric acid with potassa; and there is no occasion to use the longer expression, nitrate of protoxide of potassium; but there is no single word to designate the protoxide of iron, such, for example, as *ferra* would be, if I may be allowed to coin a word merely for illustration; and hence the compound of this oxide, with nitric acid for example, can be expressed with precision, only by saying, nitrate of protoxide of iron.

I have no doubt that, in teaching chemistry, it would promote the progress of the student to use the full name, and not the elliptical expression, in designating the salts. A few more words would be required to express the fuller name; but the advantage of precision would be gained, and many misconceptions on the part of the student avoided.

In treating of the individual elements, I shall adopt the usual primary division of them into non-metallic and metallic. A strict method will be pursued in treating of their combinations. No compound will be taken up, of which the elements are not previously described. I need not stop here to remind you, how important this part of chemistry is to the physician. Both the metals and non-metallic bodies furnish a large and important class of remedies, which deserve to be carefully studied. This department is called inorganic chemistry, to distinguish it from the chemistry of those substances which form the material parts of organized beings.

Organic chemistry is usually divided into vegetable and animal chemistry; but it is impossible to follow this division in teaching; as many organic substances are common to both the vegetable and animal kingdoms.

I wish, gentlemen, that the occasion and the allotted time permitted of my giving a sketch of the progress which organic chemistry has made within a few years. In the

absence of the power to execute such a sketch, I may be indulged with a few desultory observations, bearing on the subject. The remarks I shall make may furnish materials for thinking; and, if too disjointed to be easily remembered, may serve, at least, to convince you of the indispensable importance of organic chemistry to the medical man.

I shall treat of organic chemistry under the four heads of organic acids, organic bases, neuter substances, and colouring substances; and conclude my course with as full a consideration of the applications of chemistry to physiology and pathology, as the time will permit.

Chemistry, as applied to physiology and pathology, is as yet an infant science; but one the progress of which has been truly astonishing. It is to be regretted, however, that several cultivators of this branch of chemistry have been betrayed into hasty generalizations, which are not borne out by reason and experience. It is well known that animals are well nourished by substances containing albumen, fibrin, and casein, in other words, by the protein-compounds; and the result is explained by the fact, that these substances are identical, in composition, with the blood. From these facts, Liebig and his followers have hastily concluded, that gelatin, not being a protein-compound, can serve to form the gelatinous tissues only and not the blood, and, therefore, is not competent to nourish an animal. In support of this view, Liebig alleges that animals die from starvation, when kept on an exclusive diet of gelatin, and I believe the fact is true; but, unfortunately for the argument, it was found by Tiedemann and Gmelin that they equally perish, when fed on an exclusive diet of white of egg. The truth probably is, that animals require a mixed diet, and are, therefore, not well nourished by any single substance, when exclusively given, however nutritious it may be.

You will find, gentlemen, in works on animal chemistry, many chemical formulæ, in which the transformations of the blood into certain excrementitious matters are attempted to be traced. I have no confidence in these formulæ.

Their truth must be regarded as a mere possibility, and by no means as probable. The chemists who invent them, feel themselves at liberty to add or subtract as many equivalents of oxygen, hydrogen, &c., as may be necessary to support their preconceived opinions. Grant them this latitude, and they can prove anything they please.

The healthy and diseased states of the blood have been made out almost exclusively by chemical analysis. In a former Introductory I noticed the principal results of Andral and Gavarret, in relation to the composition of the blood in health and disease. Since then a number of chemists have entered the same path of inquiry, among whom may be mentioned Simon, of Berlin, and Becquerel and Rodier, of Paris. These chemists have followed the general plan of analysis pursued by Andral and Gavarret, which consists in determining the relative proportion of the fibrin, solid residue of the serum, blood-corpuscles, and water. In comparing the different analyses, the hæmato-globulin of Simon, although it does not include the nuclei and capsules, must be taken as equivalent to the blood-corpuscles of the French chemists. These corpuscles, as seen under the microscope, are in the form of flattened discs of a yellow colour. When blood is mixed with a serous or watery fluid, their discoid form is lost. If, however, a solution of common salt be added, their characteristic form reappears. It is well known that iron is present in the hæmatin, generally called the hæmatosin of the blood. It probably exists there as metallic iron; that is, without being in any particular state of combination; just as sulphur exists in albumen, or white of egg. Associated with hæmatin is a brown colouring matter, called by Simon, hæmaphæin, which is considered by Marchand as hæmatin modified by an alkali.

The limits within which the composition of healthy blood varies are narrow; and, consequently, a decided deviation from the normal proportion of its constituents may always be taken as a sign of disease. According to Becquerel and Rodier, the amount of blood in plethora is merely increased, while its composition is unaffected, contrary to the

opinion of Andral and Gavarret, who characterized it as containing an excess of corpuscles. In diseased blood, the fibrin and corpuscles deviate from the physiological standard in inverse proportion; for, as a general rule, in the same proportion that the fibrin is increased, the corpuscles are diminished. In inflammatory disorders, the fibrin increases with the intensity of the disease. On the contrary, in typhoid fever, the same constituent diminishes with the progress of the malady, and increases during convalescence. Becquerel and Rodier found that repeated bleedings, besides rendering the blood watery, causes a great diminution of the corpuscles; while it has no effect on the fibrin, and but slightly lessens the amount of the albumen. Herberger analyzed the blood of a chlorotic girl, before and after an eight weeks' course of chalybeates, and found, at the second period, the constituents of the corpuscles, that is, the hæmatin and globulin, more than doubled. In relation to the medical employment of iron, Simon reminds us that the metal is but slowly assimilated, and cautions us against the use of large doses, as apt to derange the digestive organs, without being more efficacious than small ones. While iron increases the amount of the blood-corpuscles, the slow influence of lead, on the contrary, diminishes them.

In diabetes, it is now well established that sugar exists in the blood, though in extremely minute proportion. To detect this substance, it is necessary, according to Bouchardat, to use blood drawn several hours after dinner, and not in the morning fasting. The best test for sugar, whether in the blood or urine, is that of Trommer. It is applied by adding to the suspected liquid, a few drops of a solution of the sulphate of oxide of copper, and afterwards sufficient solution of caustic potassa, to render the whole strongly alkaline. A grayish-green precipitate immediately falls, which, if sugar be present, redissolves, forming a blue liquid. On gently heating the mixture nearly to ebullition, the copper falls as a suboxide, forming a red precipitate. If sugar be not present, the copper is deposited in the form of black oxide.

No fact is better established in medicine than that foreign substances are capable of entering the blood. Biliverdin, one of the constituents of bile, has been found in it, by Simon, in a case of land scurvy; and Enderlin has detected minute quantities of choleate of soda (the pure bile of Demarçay) in the blood of inferior animals. In cases of jaundice, the brown pigment of the bile, called biliphæin, is found in the blood. It is probable, however, that a considerable quantity of bile cannot enter the blood without producing death; for, it has been well ascertained that this secretion has the power of dissolving the blood-corpuscles. Medicines very frequently pass into the blood, and, no doubt, act through it, as an intermedium, in modifying vital action. A curious case is given by Simon, where the fat of the blood, drawn from a patient, while under a course of cod-liver oil, had strongly the odour of the volatile fatty acid of that oil. Some medicines, as, for example, the astringents, never enter the blood; because, before they can reach the vital fluid, they form insoluble compounds with the protein-principles. It is the opinion of Mulder, that a less amount of tannin than is contained in an ounce of Peruvian bark, would, if conveyed directly into the blood, cause instantaneous death.

In respiration, atmospheric air and blood undergo remarkable changes, which can be elucidated only by chemistry. It is calculated that, in the lungs of an adult, the air and blood, separated from each other by a moist membrane only, of extreme tenuity, exert a mutual action over the immense surface of 1400 square feet. The more obvious phenomena are the disappearance of a certain amount of oxygen, and the extrication of about an equal volume of carbonic acid. The most reasonable view of what happens in this process, is that of Magnus. He conceives that the oxygen is absorbed, not chemically combined, in the lungs, and becomes carbonic acid in the capillaries. His experiments lead him to suppose, that the venous blood in the lungs absorbs an amount of oxygen, equal to about half the quantity represented by full saturation; the other half

already existing in it, when it reaches the pulmonary organs. But the same blood has absorbed the carbonic acid formed in the capillaries; and it is this carbonic acid which is exchanged for the oxygen absorbed in the lungs. Thus, by a kind of gaseous diffusion, carbonic acid and oxygen exchange places through the moist membrane, forming the parietes of the pulmonary air-cells.

As might be supposed, the amount of carbonic acid, exhaled from the lungs, varies with the age and sex. Numerous experiments have been made, in relation to this subject, by Andral and Gavarret, and Scharling. The amount of acid is altered also by disease. In confluent small-pox, measles, and chronic diseases of the skin, it is said to be increased, in typhus diminished, and in diabetes unaltered.

Intimately connected with respiration, is the subject of animal heat. Time does not permit me to dwell upon this interesting point of physiological chemistry. It is certain, however, that the combination of the oxygen, absorbed during respiration, with carbon and hydrogen respectively, forming carbonic acid and water, is the chief source of animal heat; but not the exclusive one, as Liebig has endeavoured to prove. This chemist, in order to support his views, alleges that Lavoisier and La Place underestimated the amount of caloric, given out during the combustion of carbon and hydrogen. The balance of animal heat, not accounted for by the formation of carbonic acid and water in connexion with respiration, may be supposed to have its origin in the destruction of the tissues, which is incessantly going on as a chemical process, under the control of the vital forces. It is a well-ascertained fact, that there is a consumption of tissue in muscular action, and a change in the chemical composition of the acting muscle; and Becquerel and Breschet have shown, by means of the thermo-electric multiplier, that each contraction of a muscle is attended by an increase of temperature, amounting to from 1·8 to 2·6 degrees. According to the recent experiments of Du Bois Reymond, of Berlin, muscular contraction developes electricity; and it has been long known that an electric current

excites muscular contraction. The observation of Rey-mond, if confirmed, will show that muscular contraction and an electrical current are mutually cause and effect. Some doubt, however, may be entertained in relation to its accuracy; since neither Becquerel nor Despretz were successful in repeating his experiments.

Chemistry has thrown much light on the nature of saliva, gastric juice, and bile. The characteristic organic principle of saliva is ptyalin. The presence of sulphocyanogen in healthy human saliva, is a curious fact, the truth of which has been set at rest by the analytic examinations of Wright and Pettenkofer. Mialhe announced the existence, in saliva, of a principle resembling diastase; since it possesses the power of converting starch into dextrine. To test the accuracy of Mialhe's observation, Lassaigne submitted starch to the action of human saliva, at the temperature of the body, without any change being induced in it; but, at a higher temperature, the conversion into dextrine rapidly took place. Thus, it appears, that this property of saliva, inasmuch as it is not developed at the temperature of the human body, can have no influence in digestion, contrary to the opinion of Mialhe.

The characteristic organic principle of the gastric juice is a substance, having an extraordinary solvent power, called pepsin by its discoverer, Schwann. This principle, however, has never been isolated; and Berzelius suggested that it may consist of a mixture of several substances. Liebig denies its existence as a distinct proximate principle, and states his belief that the solvent power, attributed to it, is mainly possessed by a substance, which is derived from the lining membrane of the stomach, and which, during its own progressive decomposition, transforms, by a propagated molecular action, the alimentary mass into soluble substances. The most remarkable property of pepsin is its variable digestive power, according to the menstruum in which it is contained. When its solution is acid, as it exists in the gastric juice, it dissolves nitrogenous substances, such as the protein-compounds, but exerts no action on starch. On the

contrary, when it is rendered alkaline, it dissolves starch readily, but refuses to act on nitrogenous substances. For these important facts we are indebted to Bernard and Barreswil.

Much controversy has existed in relation to the cause of the acid reaction of the gastric juice; and, no doubt, this has partly arisen from the variable qualities of the secretion itself. This reaction is attributed by Prout to muriatic acid, by Blondlot to the acid phosphate of lime, and by Bernard and Barreswil to lactic acid. The latter chemists appear to have proved that the normal acid of the gastric juice is the lactic; and their conclusions are supported by the experiments of Dr. R. D. Thomson, of Glasgow. Bernard and Barreswil show, by their decisive experiments, not only that Blondlot was wrong in his conclusions, but what was the source of his errors.

Liebig, after having denied the presence of lactic acid in the animal fluids for many years, notwithstanding the decisive experiments made by Berzelius, as early as 1807, in proof of its presence, comes forward, in December, 1846, with his own proofs of the existence of this acid in the animal fluids; alluding to Berzelius, as having merely attributed the acid reaction of recent flesh to lactic acid, without having proved its presence by unquestionable analytic results. Berzelius, in his Annual Report of the Progress of Chemistry, presented to the Swedish Academy in March, 1847, justly complained of this attempt, on the part of Liebig, to appropriate this discovery to himself.

The analysis of the bile has caused much perplexity to the chemist; and some points, in relation to its composition, are still a subject of controversy. The great difficulty of examining it, arises out of the fact of its proneness to change, both by the action of time, and by the agents employed in its analysis. The view taken by Berzelius is, probably, the correct one, that its essential constituent is a compound of soda with a peculiar organic substance, to which he has given the name of bilin. The examination of bile, by Platner, leads virtually to the same view. The bilic acid

of Kemp is, probably, the bilin of Berzelius in an impure state; but Kemp is not willing to admit the assertion of Liebig, that it is identical with the choleic acid of Demarçay. The other acids, mentioned in chemical treatises as constituents of the bile, are all, or nearly all, products of its transformation, the result either of keeping, or of the agents employed in its analysis.

Among the products of the transformation of bile, is taurin, a substance proved by Redtenbacher to contain more than 25 per cent. of sulphur, the presence of which had not been before suspected. In the analyses previously made by Demarçay and Dumas, the oxygen was estimated by the rule of difference; and, hence, what was assumed to be oxygen, was really the weight of the oxygen and sulphur taken together. This error caused them to report the proportion of oxygen to be above 60 per cent. In commenting on these analyses at the time they were made, Berzelius sagaciously observed that it was very remarkable that a neuter substance, like taurin, should contain so large a proportion of oxygen. The analysis of Redtenbacher, just mentioned, clears up this difficulty. As taurin is a product of the transformation of bilin by chemical agents which do not contain sulphur, it follows necessarily that bilin itself must contain that element; as Lehmann always asserted, before the experiments of Redtenbacher on taurin were made.

Urine is essentially a weak aqueous solution of urea. About half of its solid constituents consists of urea; the other half of salts. Simon inclines to the opinion of Berzelius, that a portion of the sulphates and phosphates, found in the urine, owe their origin to the oxidation of the sulphur and phosphorus of the protein-compounds. The quantity of urea, discharged by a healthy man in 24 hours, amounts, on an average, to a little more than an ounce. In analyzing the urine, the amount of the urea is estimated from the nitrate, assumed to contain 49 per cent. of this principle; but Marchand has shown that the nitrate, usually separated in analysis, contains only 34 per cent. If these results are finally confirmed, the estimated proportion of urea in healthy urine must be reduced. Ragsky and Heintz agree with

Marchand that the ordinary method of estimating the urea is inaccurate, and propose to determine its proportion by decomposing it by sulphuric acid, and estimating the urea from the ammonia produced, obtained as a constituent of the ammonio-chloride of platinum. Urea causes common salt to crystallize in octohedra instead of cubes; and this peculiarity of its action forms a microscopic test of urea, when searched for in animal fluids.

According to Liebig, the reaction of urine, whether acid, neutral, or alkaline, depends entirely upon the nature of the food; an animal diet tending to produce an acid, a vegetable diet, an alkaline reaction. Vegetable aliments uniformly contain vegetable acids, united with alkalies, forming salts, which, from the destruction of the vegetable acid during digestion, enter the urine as alkaline carbonates. It is, however, certain, that healthy urine usually manifests an acid reaction. The cause of this reaction is matter of dispute. Uric acid is admitted to be an invariable constituent of healthy urine, and Liebig has proved the presence of hippuric acid also; but it does not follow that they are in a free state. On the contrary, Liebig believes that they decompose the phosphate of soda of the urine, forming urate and hippurate of soda, and leaving the acid phosphate of the same base. If this view be admitted, the acid reaction of the urine is not derived from a free acid, but from an acid salt.

When salts are prescribed with a view to produce diuresis, they should be used in weak solution. When thus employed, they readily enter the circulation, and pass off by the kidneys; whereas, if used in strong solution, they fail to be absorbed, and, therefore, prove purgative. This result is explained by alleging that the blood cannot readily absorb a saline solution stronger than itself. These principles serve to explain the modus operandi of mineral waters as diuretics.

The chemical examination of the urine throws a flood of light on the pathology of many diseases. In cases of urinary sediments, chemistry is our chief guide. The amorphous sediment of a yellow, or reddish colour, occurring in acid urine, consists of urate of ammonia, and not of uric

acid; as may be proved by the fact of its ready solubility, when the urine is warmed. In gouty inflammation of the kidneys, the urine often contains shining red crystals of uric acid, even at the moment of its discharge. Benzoic acid was supposed, at one time, to have the power of diminishing the morbid excess of uric acid in the urine; but Simon has proved that this is a mistake. Nevertheless, the administration of benzoic acid in gout and chronic rheumatism, has been found useful by Froriep, although it aggravated the symptoms during the first day of its exhibition.

The presence of albumen in the urine always indicates serious disease. In Bright's disease, when fully formed, it is always present in large quantity, associated with a decrease in the density of the serum, in consequence of a deficiency of albumen in the blood. In dropsy, occurring independently of disease of the kidneys, albumen does not pass off by these organs, but is then found in large quantity in the effusions. In certain affections of the brain, and of the kidneys and bladder, the urine becomes quickly alkaline. The same is the case in paraplegia, following injury of the spine.

If time permitted, I might speak of the advantages to be derived from the chemical examination of the urine in diabetes, rickets, and many other diseases; but enough has been said, I trust, to answer the purpose of these desultory remarks.

Thus, gentlemen, I have presented to you a number of pathological facts and therapeutic indications, all tending to show the importance of chemistry, as a branch of medical study. May I be permitted to hope that I have convinced you by these illustrations, that chemistry forms one of the foundations on which the science of medicine rests, and that you cannot exercise your destined profession, usefully and respectably, without mastering its principles. If I have satisfied you on this point, I shall feel assured that you will enter upon your chemical studies in the proper spirit. On my part I promise to employ my best exertions for your improvement. Let us mutually pledge ourselves to do our duty, and all will be well.